NACE SP0187-2017
Item No. 21034
Revised 2017-03-16
Revised 2008-06-20
Reaffirmed 2005-04-07
Revised 1996-03-30
Reaffirmed 1990-09
Approved 1987-04

Design for Corrosion Control of Reinforcing Steel in Concrete

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ABSTRACT

Revised in 2017! The purpose of this NACE International standard is to give designers and facility owners design methods for controlling corrosion of proposed reinforced concrete structures. This standard presents corrosion control methods that are applicable to structures made of steel-reinforced portland cement concrete. These methods provide the designer with information about the causes of and control methods for the corrosion of reinforcing steel in portland cement concrete structures. Reinforced concrete (RC) parking structures, bridges and roadways, buildings, wastewater and water facilities, marine structures, pipe, storage facilities, and other reinforced concrete structures are being damaged by the corrosion of the reinforcing steel.

KEYWORDS

admixture, bond stress, carbonation, cathodic protection, chloride, concrete corrosion inhibitor, embedment, metakaolin, pozzolan, service life, surface coating, TG 290.

ISBN 1-57590-012-2

Foreword

In NACE standards, the terms shall, must, should, and may are used in accordance with the definitions of these terms in the NACE Publications Style Manual. The terms shall and must are used to state a requirement, and are considered mandatory. The term should is used to state something good and is recommended, but is not considered mandatory. The term may is used to state something considered optional.

Corrosion of reinforcing steel in concrete is a serious problem in certain environments. The major cause of reinforcing steel corrosion is the presence of significant amounts of chloride or other aggressive ions at the surface of the steel. Reinforced concrete (RC) parking structures, bridges and roadways, buildings, wastewater and water facilities, marine structures, pipe, storage facilities, and other reinforced concrete structures are being damaged by the corrosion of the reinforcing steel.

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This NACE standard was originally prepared in 1987 by NACE Task Group (TG) T-3K-5, a component of Unit Committee T-3K on Corrosion and Other Deterioration Phenomena Associated with Concrete. To provide the necessary expertise on all aspects of the subject and to provide input from all interested parties, Task Group T-3K-5 was composed of corrosion consultants, consulting engineers, designers, cathodic protection (CP) engineers, researchers, structure owners, and representatives from industry and government. This standard was reaffirmed in 1990 and revised in 1996. It was reaffirmed in 2005 by Specific Technology Group (STG) 01, "Reinforced Concrete." It was revised in 2008 and 2017 by TG 290, "Reinforced Concrete: Design Considerations for Corrosion Control"; and is sponsored by STG 41, "Electric Utility Generation, Transmission, and Distribution." It is published by NACE under the auspices of STG 01.

NACE International Standard Practice (SP0187-2017)

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Tables

Section 1: General

1.1 This standard presents corrosion control methods that are applicable to structures made of steel-reinforced portland cement concrete.

1.2 State of Steel in Concrete

1.2.1 Reinforcing steel is compatible with concrete not only because of similar thermal expansion properties, but also because the highly alkaline pore solution in portland cement pastes allows a stable, protective oxide film to form on the surface of the encased steel.

1.2.2 If the protective oxide film does not form on the steel surface or if it does not protect the whole surface of the steel, corrosion can occur. Corrosion of the reinforcing steel can cause cracking and spalling of concrete, weaken its load-bearing capacity, or even cause loss of structural integrity.

1.2.3 The protective oxide film on the steel surface may not be formed or may be destroyed if (1) the concrete does not fully encase the steel, (2) alkalinity is lost by reaction with aggressive substances (such as carbon dioxide), or (3) excessive amounts of chloride or other aggressive ions are present in the vicinity of the steel. If any of these conditions exist, and both sufficient moisture and oxygen are in contact with the steel, corrosion can occur.

1.2.4 Corrosion proceeds by the formation of an electrochemical cell, including anodic and cathodic areas that are electrically coupled on the metal, with the pore solution of the cement paste acting as the electrolyte. If any one of the elements of the electrochemical cell is eliminated, corrosion can be prevented.

1.2.5 Other forms of corrosion such as those caused by dissimilar metal couples or stray currents[1] can initiate or accelerate corrosion.

1.3 Damage to Concrete Caused by Steel Corrosion

The corrosion process can damage concrete in several ways, including cracking, loss of bond, and localized corrosion.

1.3.1 Cracking

The corrosion products of steel often occupy several times the volume of the base metal. The expansive pressure because of this volume increase exerts a significant tensile force on the surrounding concrete. Resulting cracks propagate toward either the concrete surface or nearby reinforcing steel, causing delamination. A small loss of steel can cause concrete delamination, but structural integrity is largely retained until corrosion has removed a significant amount of reinforcing steel or concrete.

1.3.2 Loss of Bond

Bond stresses and corrosion both put concrete in tension and are additive. Even minor metal loss at the surface of the reinforcing steel can be sufficient to crack the concrete cover and cause loss of bond. Other problems caused by loss of cover include spalling and falling concrete, increased steel corrosion, and reduction in the structural integrity of the structure.